



Multi-Layer Network Automation

Loudon Blair

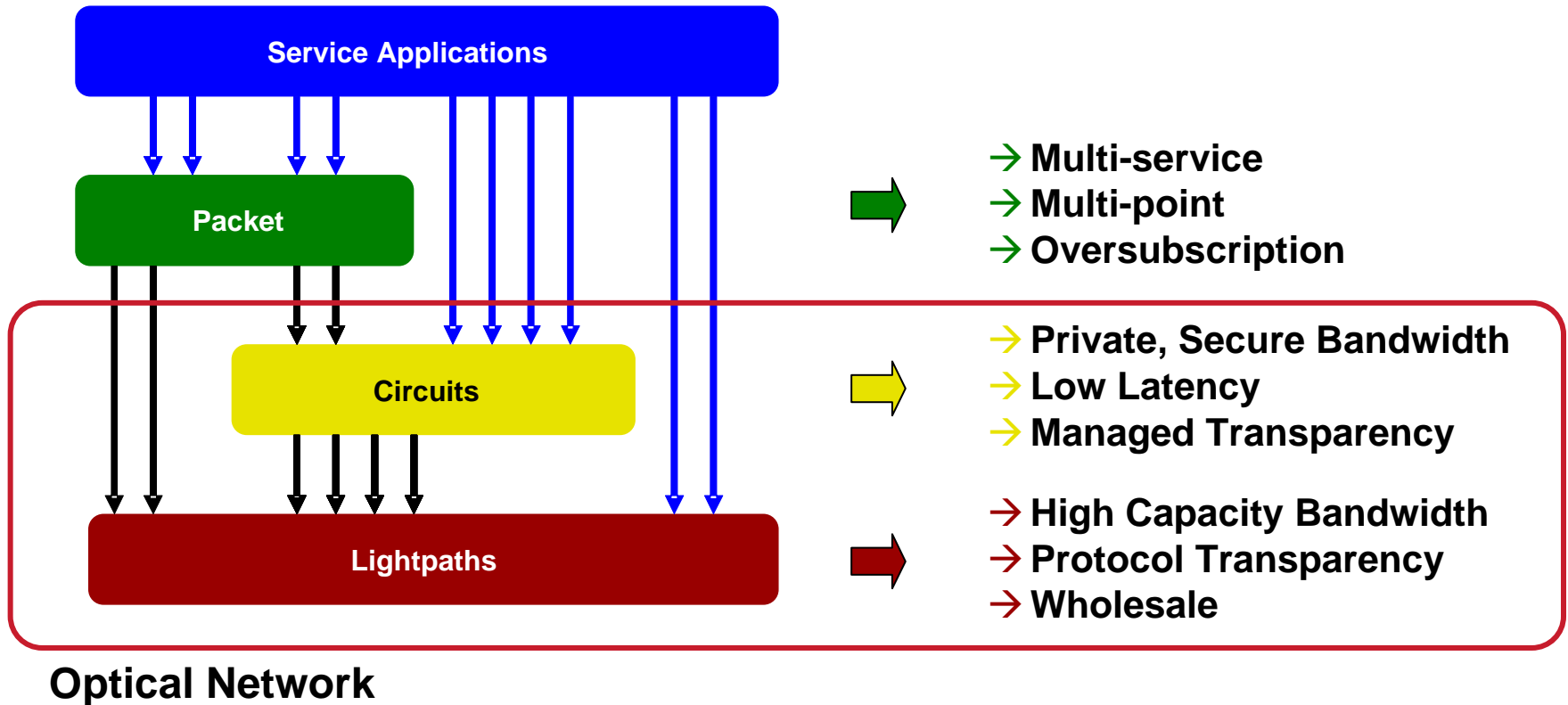
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Symposium: Dynamic Multi-Layer Mesh Network ... Why, How, and When?

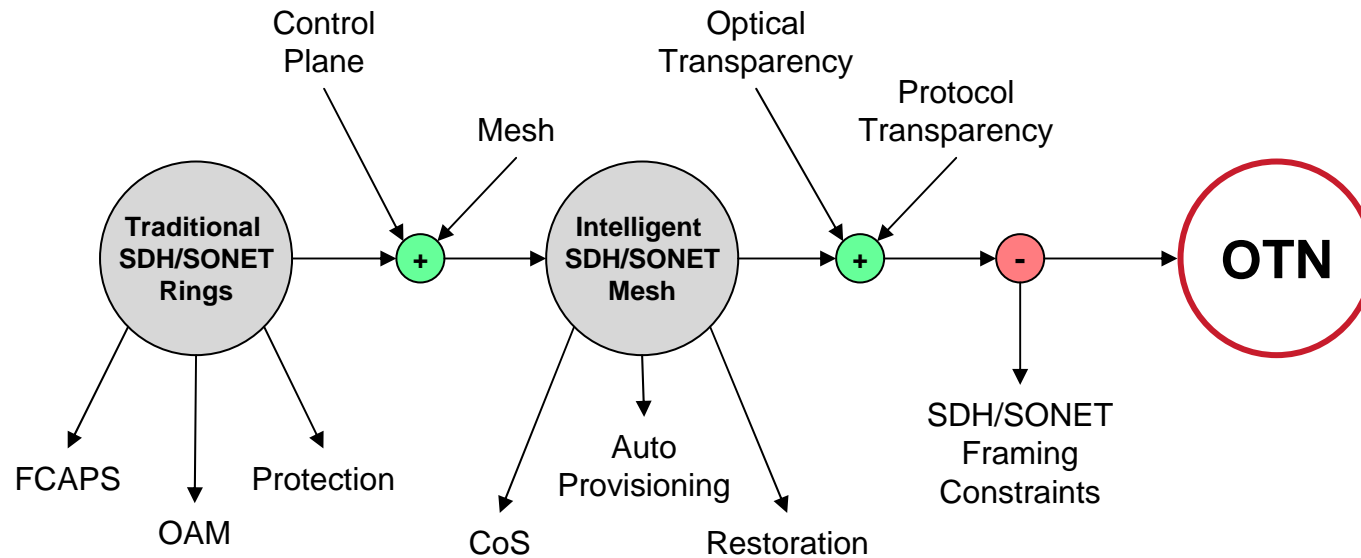
ECOC 2009, Vienna, Austria, 23rd September 2009

Multi-Layer Network

Service or Infrastructure | Client or Server

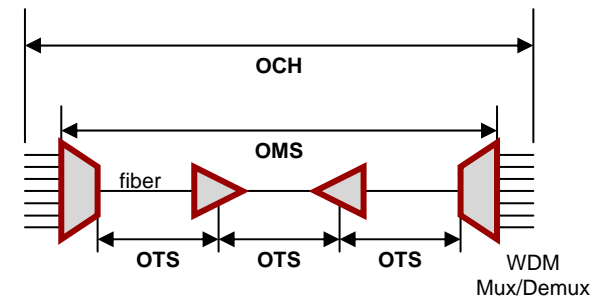
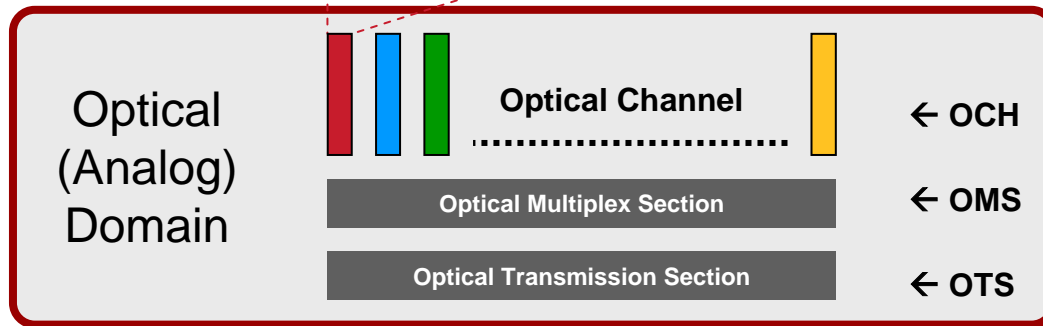
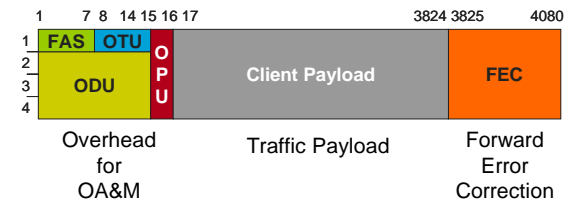
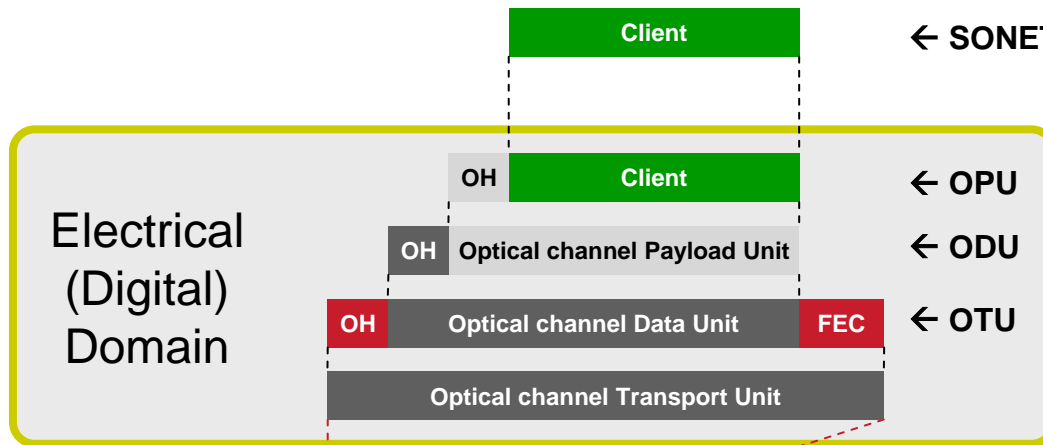


Optical Network Evolution



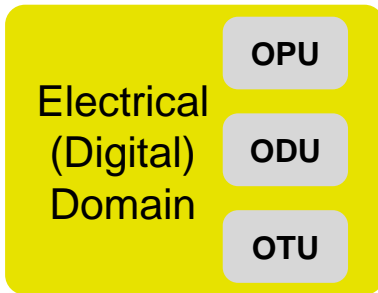
OTN will replace SONET/SDH as foundation for optical services

Optical Transport Network (OTN) Definition

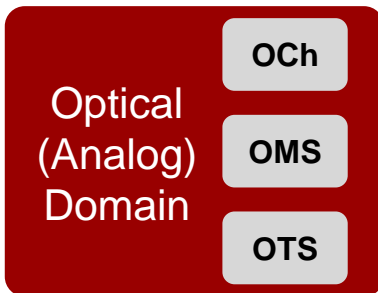


OTN standards defined by ITU-T G.872 and G.709

OTN Behaviors



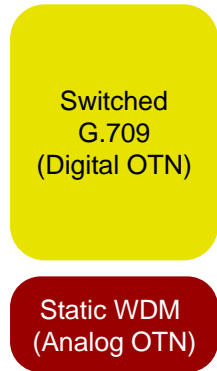
- Client Transparency
- Sub-Wavelength ODU Switching
- High Efficiency Grooming
- Pre-established Physical Links



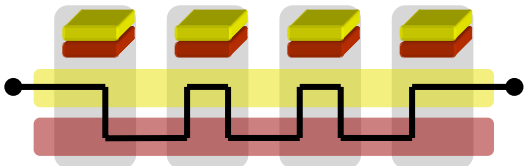
- Client Transparency
- Full-Wavelength OCh Switching
- Wavelength Selective Bypass
- Unverified Physical Links

Three Architecture Options for OTN

A



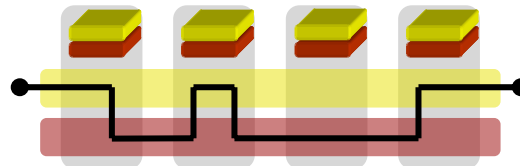
- G.709 provides all dynamic capabilities
- WDM for capacity only



B



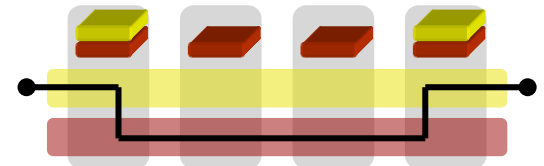
- G.709 provides dynamic switching
- WDM with reconfigurable connections



C

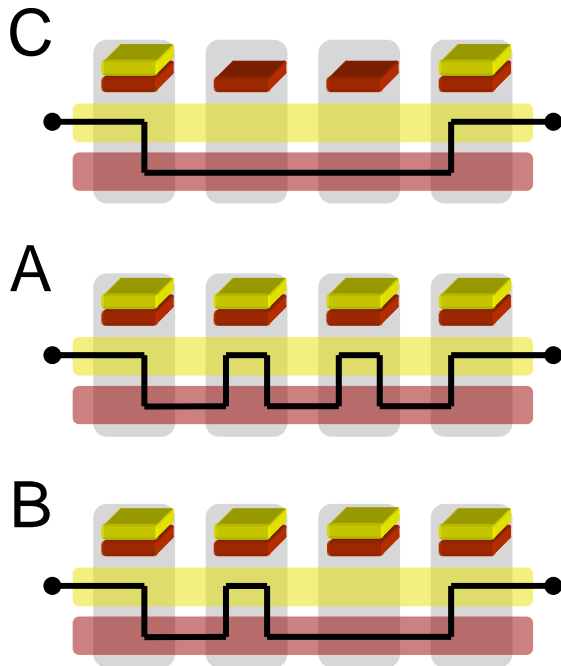


- G.709 provides framing only
- WDM for all dynamic capabilities



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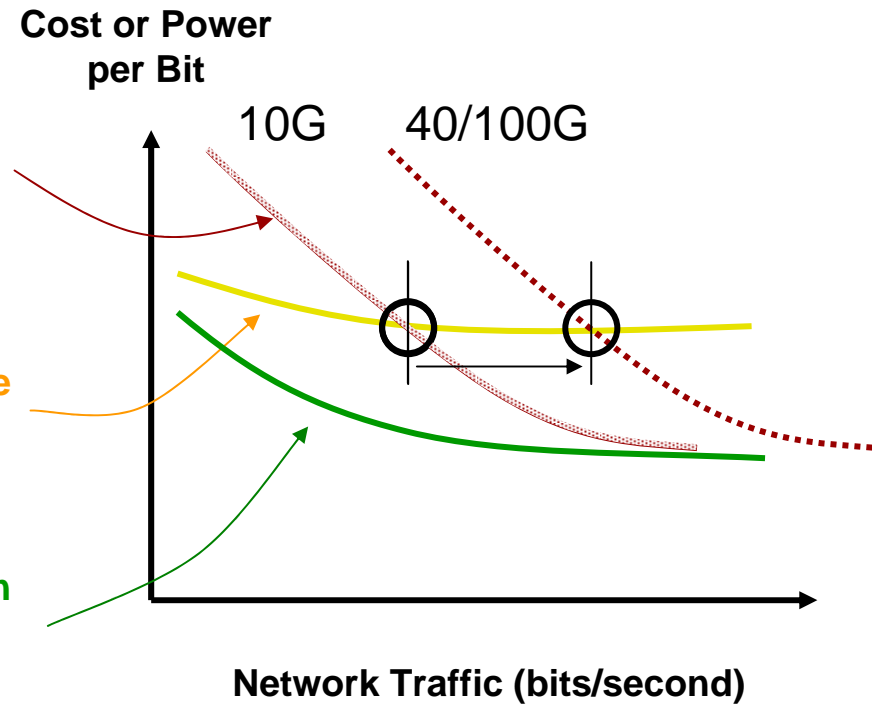
OTN Economics & Power



Optical Wave
Switching Only

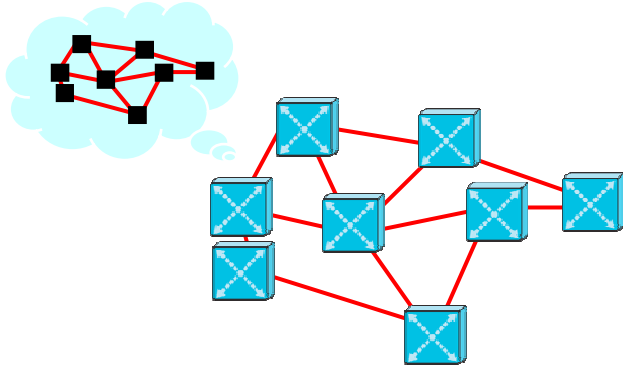
Electrical Sub-Wave
Switching Only

Hybrid Combination
Wave + Sub-wave
Switching

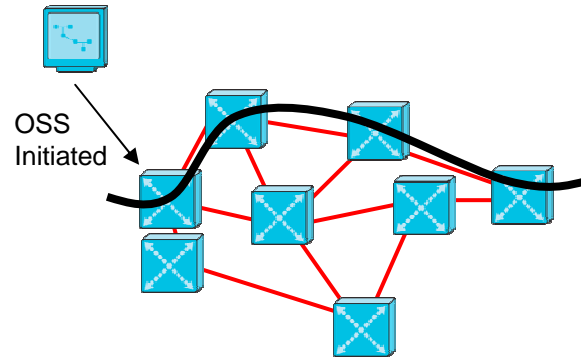


Important Conclusion: Stay on the Green Line

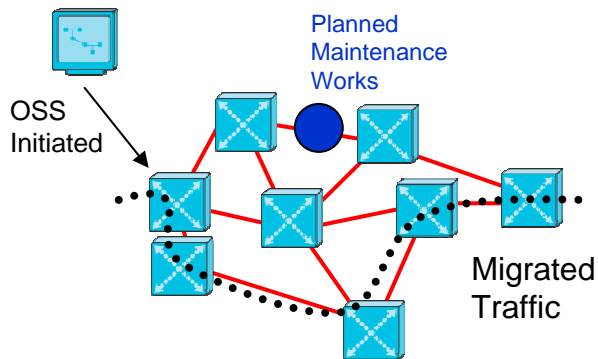
Control Plane Applications



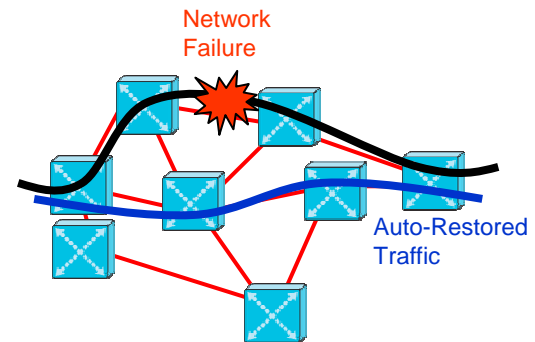
1. Automated Self-Inventory



2. Automated Connection Management

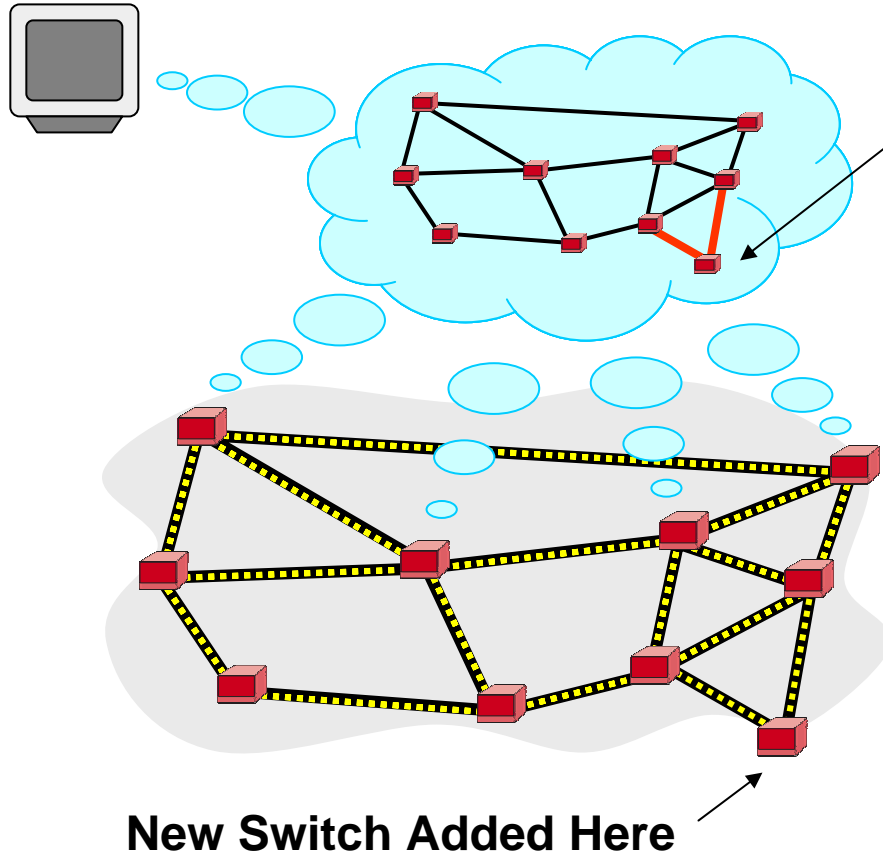


3. Efficient Operations



4. Self-Healing Network

1. Automated Self-Inventory



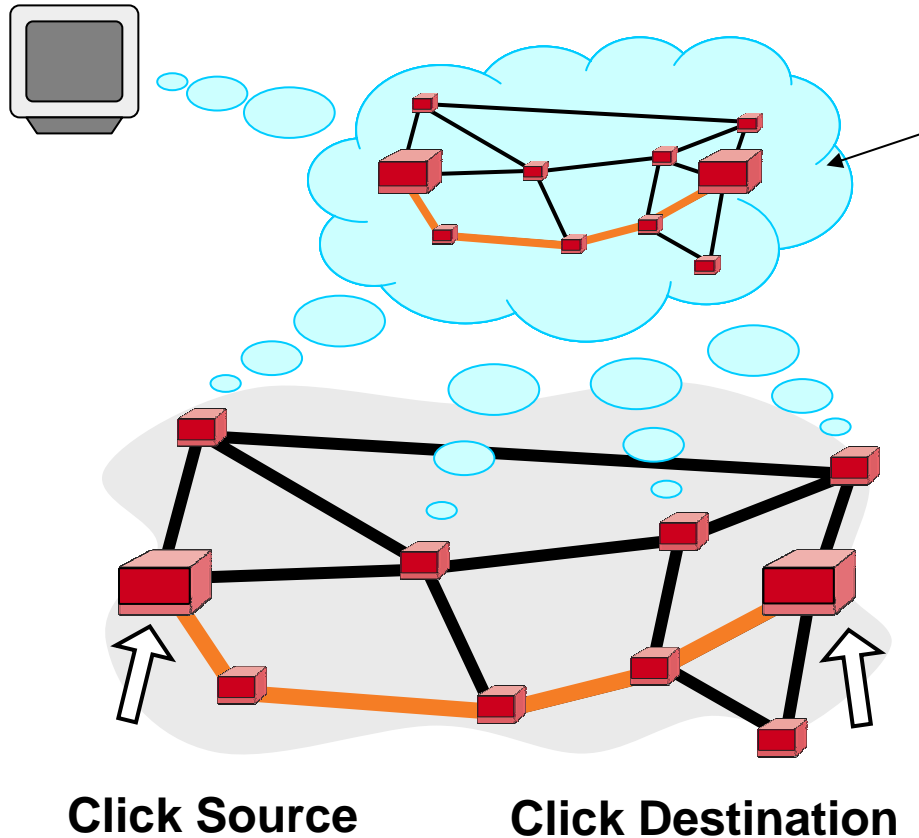
Automatic Topology Update

Network is Database of Record

- Discover network element capabilities and availability
 - Discover neighbor connections
 - Identify peer level port associations and network layer client-server relationships
- Distribute data to NEs and NMS
 - Communicate network state updates
 - Create accurate & timely topological and resource maps
- Client inherits common server characteristics
- Define service-to-connection associations
 - Customer service and SLA tracking

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2. Automated Connection Management

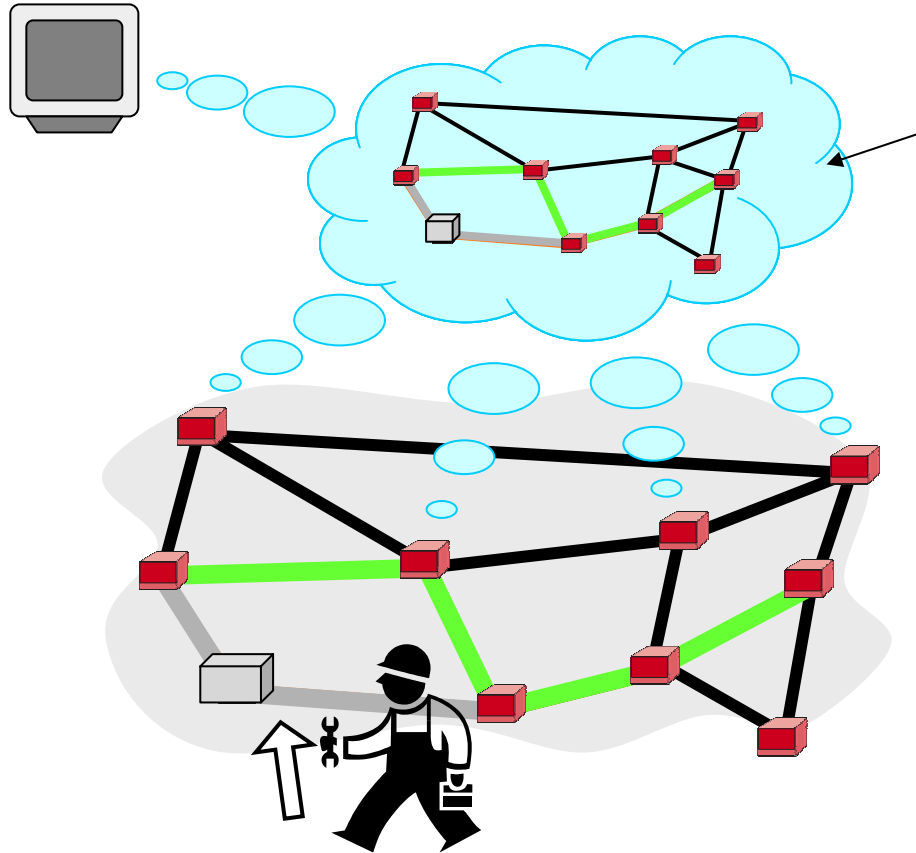


✓
Connection Confirmed

Point & Click Connections

- Automate turn-up and tear-down of connections
 - Signaled or Soft-permanent
 - Fast service activation
- Coordinate services across Packet, Circuit and Wavelength layers
 - Heterogeneous infrastructure
 - Lowest cost routing
 - QoS awareness
- Multi-layer complicates path computation
 - Digital connection routing
 - Analog connection routing
 - Wavelength assignment
 - Optical impairment verification

3. Efficient Operations



Switch off Node for Maintenance

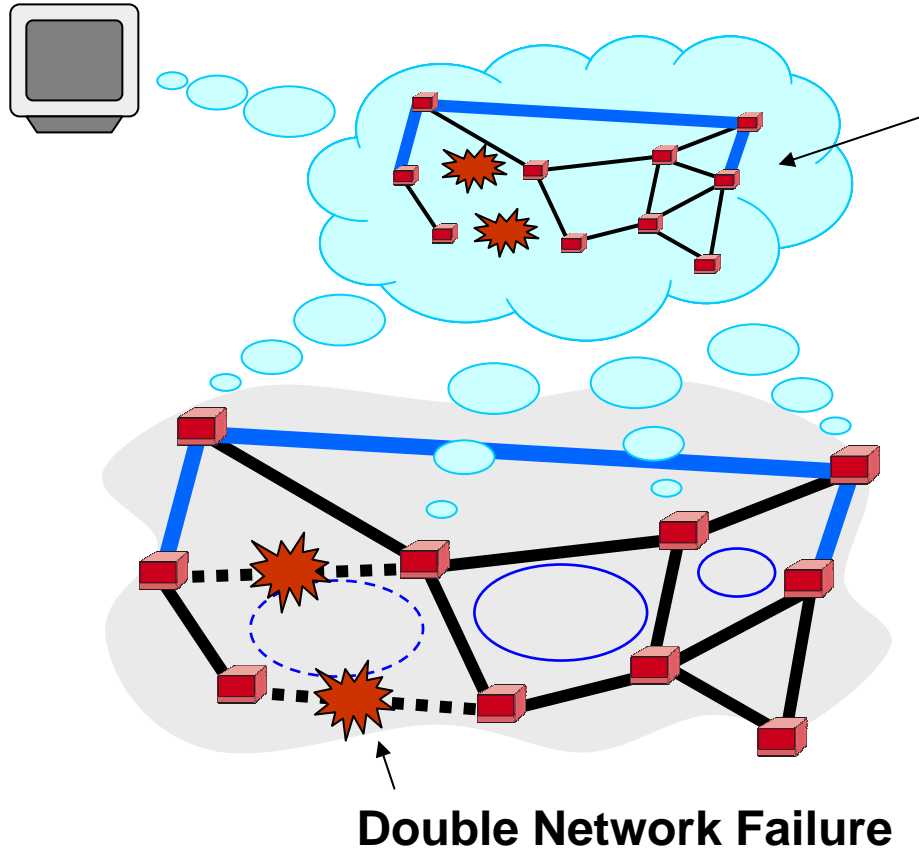


Traffic Redirected for Maintenance

Planned Traffic Migration

- Close cooperation between network planning & field operations
 - Design tool planning
 - Control plane execution
- Planned Line Maintenance
 - Temporary re-route of traffic around maintenance event
 - Temporarily disable links/nodes from use
- Network Defragmentation
 - Multi-layer traffic optimization
 - Periodically re-groom traffic on to cost-efficient connections as demands change
 - Increases resource utilization & minimizes cost per bit (Remember: Stay on Green Line)

4. Self-Healing Network



✓
Connection Restored (Again)

Disaster Recovery

- Mesh restoration across single- and multiple- administrative domains
- Sequence of multi-layer survivability
 - Optical layer first, packet layer second
 - Packet layer first, optical layer second
- Re-establishment of protection path
 - Improve connection availability by restoring BACKUP path of failed 1+1
- Multi-layer control communication
 - Layer decision: Hold off timers
 - Service priority: Contention control
 - Real-time alerts: AIS, Pre-FEC BER
 - Routing impact: Latency, SRLG

Summary

New Breed of Network Elements that participate in Multiple Network Layers

→ Includes Packet, Circuit and Lightpath

Multi-Layer Switching Improves Cost & Power per Bit

→ Hybrid Combination of Electrical and Analog OTN Networking

Four Applications for Control Plane Automation

- Automated Self-Inventory
- Automated Connection Management
- Efficient operations
- Self-Healing Network



Thank You

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